A STUDY OF THE EFFECTS OF THREE DIMENSIONS OF INSTRUCTIONAL TIME ON ACADEMIC ACHIEVEMENT [1]

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Within the past several years attention in research on learning and instruction has turned to a factor termed "time to learn" or "instructional time" as it relates to academic achievement. It is not a new factor for educational study, as a search of the literature indicates. As early as 1915 Holmes examined instructional time by subjects and grades, and Mann's (1928) study of time usage in instruction from 1826 to 1926 acknowledged the saliency of time as an instructional factor. Interest in instructional time receives recurring attention as research into individual differences has focused on rate of learning and amount of time required to learn (Washburn,1925; Tyler, 1962; Carroll, 1963). Recent studies involving time can be sorted into two categories: time as a specific unit of measure (years, months, days, hours, minutes) related to achievement or to other selected dependent variables; and time usage in relation to curriculum and instructional concerns. The first category is represented by such studies as Hyman, Wright, and Reed (1975) and Harnqvist (1977) in their examination of the enduring effects of education in relation to years of schooling. Other studies that look at learning as a function of varying units of time are reviewed by Fredrick and Walberg.[2]

In the second category of studies, time usage is examined descriptively within curriculum and instructional contexts. The emphasis is less on a given unit of time and more on how teachers and students use the available school time for learning. A distinction is made between engaged time (time on an academic task) and nonengaged time (time use other than on an academic task).

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Students and teachers' engaged and non-engaged time behaviors are being identified (Harnischfeger and Wiley, 1976; Rosenshine and Berliner, 1978; and Stallings and Kaskowitz, 1974). Within the instructional context, a better description of time variables associated with achievement is emerging.

Direct instructional time appears to be a potent teaching variable related to the degree of student engaged time. The greater the amount of time spent by teachers on direct interaction with students in the teaching-learning process, the greater the amount of student time engaged in academic tasks (Good and Beckerman, 1978). Carried one step further, we could expect, then, a positive relationship between the amount of direct instruction and achievement. Good and Beckerman (1978) and Rosenshine (1976) report such findings.

Within the curriculum context as distinct from instruction, the direction in research suggests the need to examine the extent of content covered in a given unit of time as this relates to achievement. Rosenshine and Berliner (1978) report on studies emphasizing the instructional aspects and recommend that future studies need to examine content covered in conjunction with classroom practice and achievement.

The present study extends the previous research in the second category of time studies by examining three questions concerning time in curriculum and instructional contexts. Two of the questions relate to instruction, one to curriculum.

Identifying the Three Questions

Three dimensions of teacher time are probed as they relate to student academic achievement: direct instructional time, teacher in-school preparation time, and teacher out-of-school preparation time. In this study direct instruction is that portion of time, measured in minutes, teachers actively engage students in a planned lesson with defined cognitive objectives. Preparation time refers to teacher time spent in planning the lesson prior to instruction. Previous studies indicate a positive correlation between direct instruction and achievement. The two

types of teacher preparation time, therefore, may explain additional portions of student achievement not otherwise accounted for by direct instruction. Should this be the case, the efficacy of building in planning time in teachers' schedules could be documented.

The study did not isolate the amount of engaged time from the total number of minutes of teacher direct instruction. Each activity within the curriculum involved the teacher in direct instruction; we are assuming, therefore, that nonengaged time was at a minimum.

The first two questions under study examine time in an instructional context. The third question examines time in a curriculum context.

1. What is the relationship between the three dimensions of teacher time and academic achievement controlling for prior achievement and grade level?

2. To the first question, an additional factor is added, the classroom learning environment. Previous studies have shown a relationship between the learning environment and achievement (Talmage and Walberg, 1978; Walberg and Ahlgren, 1970 and Walberg, 1969). Therefore we need to examine that portion of achievement variance which is attributable to the classroom learning environment. Learning environment was measured by five scales on the My Class Inventory, augmented by two cognitive processes scales.[3] The question becomes, What is the relationship between the two dimensions of teacher time (direct instruction and all preparation time) controlling for prior achievement, grade and seven classroom learning environment scales?

3. The third question focuses on a curriculum issue, extent of content coverage. Content coverage is measured by the number of activities completed in each unit comprising a nutrition education curriculum. Achievement may be dependent as much on what content is covered as it is on direct instructional time. Hence the third question states, What is the relationship between extent of curriculum coverage and academic achievement controlling for prior achievement, grade, teacher direct instructional time, teacher preparation time, and learning environment.

Procedure

Students in 165 classes throughout the United States (Grades K through 6) were instructed in a nutrition education curriculum, FOOD...Your Choice (1977). The sequentially developed curriculum includes three levels (Level 1, grades K-2; Level 2, grades 3-4; and Level 3, grades 5-6). Each level contains from two to four units. No grade is assigned more than 2 units. During inservice training teachers were encouraged to complete the assigned units for a given grade within 20 hours of instruction over a three-month period. Although the number of activities within each unit differed, the curriculum developers had determined 20 hours to be sufficient time within which to carry out the total number of activities for a given grade.

Teachers were asked to keep an instructional log of time, in minutes, spent on each activity. Time data were recorded at the conclusion of each activity. Teachers recorded: 1) time spent during the regular teaching day in preparing for an activity, called teacher in-school preparation time (S-TPT); 2) time spent by teachers in out of school preparation time for each activity (0-TPT); and 3) time spent in direct instruction from the start of FOOD...Your Choice activity in class until the in-class time was terminated for a given activity (DIT).

Most teachers were observed on at least three occasions to obtain data on FOOD...Your Choice implementation.[4] The observers, on these occasions, also reviewed the Instructional Log with the respective teacher to ensure consistency in recording the time data. The logs were reviewed again during the exit interview with teachers. A nutrition education achievement test was administered prior to and following instruction in FOOD...Your Choice. Because achievement of each unit was measured by a different number of items, z scores on both the pretest and posttest were calculated for each class to make the achievement data comparable. Test reliabilities ranged from .81 to .96.[5]

Analyses and Results

Analysis of data are described under the three research questions and the results discussed.

Question 1. The five independent variables (prior achievement, grade level, DIT, S-TPT, and 0-TPT) were entered into a multiple

regression equation with post test achievement as the dependent variable. Three forms of the equation were calculated: linear, square root, and natural logarithm. Visual inspection of the independent and dependent variable residual plots of the three forms permitted the detection of normality assumption violations and suggested the selection of the root form of the model (Daniel and Wood, 1971; Walberg and Rasher, 1976), shown as Equation 1 in Table 1. All subsequent regression equations, therefore, are in root form. From Equation 1, prior achievement is significantly related to post achievement and appears to account for most of the achievement variance. Of the remaining independent variables, DIT approaches significance.

A second multiple regression (Equation 2) includes all five independent variables plus the interaction of each of the three dimensions of time with prior achievement. The resulting equation (see Table 1) has a slightly higher R^2 than does Equation 1, and the t-values of the time variables are increased. When the interactions are introduced, we observe three significant independent variables: DIT, prior achievement, and the interaction of prior achievement and DIT (see t-values, Table 1). Both O-TPT and the interaction of O-TPT and prior achievement approach significance. Equation 2 explains slightly more of the posttest achievement variance (R^2 = .554) than does Equation 1 (R^2 = .533).

Inasmuch as neither teacher in-school preparation time (S-TPT) nor teacher-out-of-school preparation time (O-TPT) has significant t-values and the intercorrelation is high, (r = .45), they were added together to create a composite variable, teacher preparation time (TPT). Equation 3 examines three independent variables and two interactions: direct instructional time (DIT), the new variable TPT, prior achievement, the interaction of prior achievement with TPT, and prior achievement with DIT. (Grade was eliminated due to its lack of significance in Equation 2). From Equation 3 in Table 1, we see that higher prior achievement, more direct instructional time, less teacher preparation time, a negative interaction of DIT and prior achievement, and a positive interaction of TPT and prior achievement significantly predict higher posttest. Each of these independent variables makes a significant contribution to predicting posttest achievement.

Figure 1 examines the interaction of DIT with prior achievement. Increased direct instructional time is positively related to higher posttest scores of students with low prior achievement, moderately related to higher posttest scores of students with average prior achievement and moderately negatively related to posttest scores of students with high prior achievement scores. Figure 2 examines the interaction to TPT with prior achievement. Increased teacher preparation time is negatively related to posttest scores of students with low prior achievement scores, unrelated to posttest scores of average pretest students, and positively related to posttest scores of higher-scoring students.[6]

Question 2. The second question adds the seven learning environment scales as variables to Equation 3. The resulting multiple regression Equation 4 (Table 1) includes the root form of DIT, TPT, prior achievement, grade, the interactions of prior achievement with DIT and prior achievement with TPT, and the seven classroom learning environment scales as independent variables, and post achievement as the dependent variable. Because of possible redundancy among the learning environment variables, and in the interest of simplifying Equation 4 by reducing the number of independent variables, we searched all possible combinations of independent variables for equations with the largest R^2 and the smallest total squared error.[7] The two best equations, 5 and 6 include all Equation 3 variables--pretest, DIT, TPT, and the two interactions--along with grade and lower thought processes. In addition, Equation 5 includes friction while Equation 6 includes cohesiveness. Although Equation 4 has a slightly higher R^2 than Equation 5 and 6, the latter two equations are more parsimonious, thus warranting replacement of Equation 4 by either Equation 5 or 6. E Apparently cohesiveness (positive) in Equation 5 is substituting for friction (negative) in Equation 6.

From Equation 5 we observe that higher direct instructional time, less teacher preparation time, higher grade levels, higher cohesiveness, greater lower thought processes, a negative interaction of direct instructional time with prior achievement, and a positive interaction of teacher preparation time with prior achievement are significantly related to post nutrition education achievement. Together these five independent variables and two interactions account

for 67% of the dependent variable variance. Substituting cohesiveness in Equation 5 for friction in Equation 6, the results are almost identical with R^2 = .671; that is, Equation 6 accounts for 67.1 percent of post achievement variance. Therefore either Equation 5 or Equation 6 best responds to question 2.

Question 3. A curriculum issue is introduced in question 3, the relationship of extent of content coverage and academic achievement.

This question was considered by examining a number of regression equations (see Table 2). First, all variables and interactions in Equation 3 (Table 1) plus grade level, content coverage, and the interaction of coverage with prior achievement were entered into a regression equation as independent variables to predict post achievement (Equation 7). As is shown in Table 2, neither coverage nor its interaction with prior achievement significantly add to the prediction of posttest scores. In Equation 8, which includes all Equation 7 independent variables plus the seven learning environment scales, again neither coverage nor the interaction of coverage and prior achievement significantly add to the prediction of the posttest.

Since coverage adds little to explaining achievement, we can either drop this variable and return to Equation 3, or we can see if content coverage and direct instructional time so strongly overlap that they can be substituted for one another. The intercorrelation of DIT with coverage is .67. This suggests the redundancy of measuring each of these variables separately. Equation 9 duplicates Equation 3 but substitutes coverage and the interaction with prior achievement for DIT and the interaction of DIT with prior achievement. Coverage is found to be a sightly weaker predictor of post achievement than DIT as is evident in the R^2 of Equation 9 (R^2 = .529) compared to the R^2 of Equation 3 (R^2 = .551).

Equation 10 duplicates Equation 5 and Equation 11 duplicates Equation 6, in both cases substituting coverage for DIT. Content coverage and the interaction of coverage and prior achievement are significant predictors of post achievement as indicated in Equations 10 and 11. Figure 3 graphically represents the interaction. Low prior achieving students obtain higher post achievement scores

controlling for teacher preparation time the more content that is covered. In effect, the graph reinforces findings from Equations 5 and 6. W could substitute DIT for content coverage. However, Equation 5 is a somewhat better predictor of post achievement than is Equation 10 (R^2 = .670, Eq. 5; R^2 = .600, Eq. 10), and Equation 6 predicts five percent more of the variance than Equation 10 (R^2 =.671, Eq. 6; R^2 = .621, Eq. 10). In addition, several variables significant in Equations 5 and 6 are not significant in Equations 10 and 11. The significant variables are summarized in Table 3. While coverage could be a possible proxy for direct instructional time, it is clear from Table 3 that either Equations 5 or 6 have better explanatory power of post achievement than Equations 10 and 11.

Discussion

Equation 3 best responds to question 1. Controlling for prior achievement and combining teacher in-school and out-of-school time as a single variable (TPT), both teacher time used in preparation for instruction and in direct instruction predict achievement. Probing the significant interaction of prior achievement with direct instructional time, we find the students with low pretest scores (low achieving students) benefit most from larger amounts of direct instruction than do students with high prior achievement scores. Higher achieving students appear not to need as much teacher attention as low achieving students. This confirms previous studies reported by Rosenshine (1976).

On the other hand the positive beta weight associated with the significant interaction of prior achievement and teacher preparation time indicates that higher achieving students benefit more from the time teachers use to prepare for instruction than do low achieving students. Although this finding may produce intuitive dissonance, further probing suggest plausible explanations. One of the objectives of the nutrition education curriculum entails engaging students actively in challenging activities (FOOD....Your Choice: Teacher's Manual, 1977). If we knew the substance of the preparation, we might find that teachers use the preparation time to work out imaginative, higher cognitive thought process activities. While challenging activities have been shown to enhance academic achievement in high ability students, the opposite is the case with low achieving students (Brophy

and Evertson, 1974). As noted in the equations where learning environment variables are entered to respond to question 2, the variable lower thought processes is positively and significantly correlated with achievement. The greater the amount of low thought process activities perceived by the students, the higher the achievement. No significant interaction was found between lower thought processes and ability level, indicating that all levels of students profitted from low thought process activities.

These findings certainly suggest the need to study the content of teacher preparation. Given a limited amount of teacher preparation time, what type of preparation activities will have the greatest payoff in achievement for different ability students?

From Equations 5 and 6 we can respond to the second question. Two environmental variables (Equation 5: lower thought processes and friction, or Equation 6: lower thought processes and cohesion; and two time variables (direct instructional time and teacher preparation time) are the best set of predictors of achievement. Further, there are differential achievement gains related to ability. For low achieving students, achievement gains are associated with greater amounts of direct instructional time and high achieving students profit from time teachers spend in preparation for instruction.

The answer to question 3 concerning the effects of coverage on achievement remains indeterminate. When direct instructional time is entered in the regression equation content coverage is not significantly correlated with post achievement. However, when direct instructional time is not entered in the equation but two learning environmental variables are, then content coverage is significantly correlated with achievement. It appears that in Equations 10 and 11, content coverage serves as a proxy for direct instructional time. This may be due merely to the type of content covered in FOOD...Your Choice, rather than a finding generalizable across other curricular contents. This does suggest an area for additional study. However, the high positive correlation between DIT and content coverage indicates that the more teachers engage in direct instruction, the greater the possibility of moving expeditiously through the learning activities.

Notes

1. Paper presented at the American Educational Research Association Conference, Division B, San Francisco, April 1979. This study was supported in part by funds from the National Dairy Council and the Office of Evaluation Research, University of Illinois at Chicago Circle.
2. Such studies were reviewed by W. C. Fredrick and H. J. Walberg in an unpublished manuscript entitled Learning as a function of time, 1978.
3. My Class Inventory contains five scales on the classroom learning environment: Cohesiveness, Competitiveness, Difficulty, Friction and Satisfaction. The two cognitive scales measure students perception of lower cognitive thought processes of classroom learning activities and higher cognitive thought processes. (See Anderson, G.J. The assessment of learning environments: A manual for the learning environment inventory and My Class Inventory. Halifax, Nova Scotia: Atlantic Institute for Education, 1971; and Steele, J.M., House, E.R., Lapan, S., and Kerins, T. Instructional climate in Illinois gifted classes. Center for Instructional Research and Curriculum Evaluation, University of Illinois, Urbana, 1970.)
4. In several cases less than three observations were made due to severe winter storms in one part of the United States.
5. For a complete report of the nutrition achievement test see Talmage, H., and Rasher, S.P. Nutrition education test item analysis for National Dairy Council, Inc., Report on Level 1. Technical Report #104, Office of Evaluation Research. Chicago: University of Illinois at Chicago Circle, October, 1978; Technical Report #105 (Level 2), December 1978; and Technical Report #106 (Level 3), December 1978.
6. It should be noted that the lowest posttest value is .874, the highest is 2.329 and the mean score is 1.710; thus, there is a slight skewing of the posttest data toward higher posttest scores. It is uncertain if this is affecting the significant interactions.
7. See Daniel and Wood, 1971 for a complete description, rationale, and examples of these Cp search techniques.

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Table 2

Relationship of Teacher Time, Coverage, Prior Achievement, Grade and Learning Environment to Academic Achievement

Equation		Pretest	DIT	TPT	Coverage	Grade	Pre* DIT	Pre* TPT	Pre* Coverage	Sat	Fric	Comp	Diff	Cohe	LTP	HTP	Constant	R^2
7	b	.882	.070	-.049	-.021	-.026	-.036	.026	.010								.197	.550
	t	(3.4)	(2.5)	(1.8)	(0.3)	(0.7)	(2.3)	(1.7)	(0.2)									
8	b	1.507	.149	-.130	.066	.272	-.075	.069	-.045	-.118	-.211	.092	-.120	.225	.623	.215	-3.879	.715
	t	(4.7)	(4.0)	(3.6)	(0.8)	(2.7)	(3.7)	(3.5)	(0.9)	(0.8)	(1.4)	(0.5)	(0.7)	(1.1)	(2.7)	(0.8)		
9	b	.891		-.013	.072			.006	-.036								.127	.529
	t	(3.3)		(0.6)	(1.1)			(0.5)	(1.0)									
10	b	1.392		-.026	.182	.189		.016	-.100					.267	.449		-3.403	.600
	t	(3.8)		(0.9)	(2.2)	(2.1)		(1.0)	(2.0)					(1.6)	(2.4)			
11	b	1.306		-.037	.200	.193		.021	-.108		-.284				.627		-2.181	.621
	t	(3.7)		(1.3)	(2.5)	(2.3)		(1.4)	(2.3)		(2.8)				(3.2)			

Table 1

Relationship of Teacher Time, Prior Achievement, Grade, and Learning Environment to Academic Achievement

Equation		Pretest	DIT	S-TPT	O-TPT	TPT	Grade	Pre* DIT	Pre* S-TPT	Pre* O-TPT	Pre* TPT	Sat	Fric	Comp	Diff	Cohe	LTP	HTP	Constant	R^2
1	b[1]	.686	.007	-.006	-.000		-.018												.507	.533
	t[2]	(13.0)	(1.8)	(1.3)	(0.1)		(0.8)													
2	b	.935	.063	-.310	-.393		-.013	-.032	.014	2.22									.074	.554
	t	(5.4)	(2.4)	(0.9)	(1.8)		(0.6)	(2.2)	(0.7)	(1.8)										
3	b	.921	.067			-.039		-.035			.020								.081	.551
	t	(5.4)	(2.9)			(2.2)		(2.7)			(2.1)									
4	b	1.227	.125			-.113	.243	-.063			.060	-.148	-.273	.144	-.154	.205	.598	.214	-3.03	.686
	t	(5.3)	(3.8)			(2.3)	(2.4)	(3.5)			(2.2)	(1.1)	(1.8)	(0.7)	(0.9)	(1.0)	(2.5)	(0.8)		
5	b	1.358	.140			-.124	.225	-.071			.065					.346	.588		-4.20	.670
	t	(6.3)	(4.4)			(2.6)	(2.8)	(4.0)			(2.5)					(2.3)	(3.1)			
6	b	1.199	.131			-.124	.193	-.066			.065		-.225				.722		-2.537	.671
	t	(5.4)	(4.2)			(2.6)	(2.5)	(3.7)			(2.5)		(2.4)				(3.9)			

$t \geq 2.00$ then $p < .05$
$t \geq 2.66$ then $p < .01$
$t \geq 3.46$ then $p < .001$

[1] b = unstandardized b-weight

[2] t = t-value

Table 3. Comparison of Significance of Variables in Equations 5, 6, 9 and 10

Variables	Eq 5 (p)	Eq 9 (p)	Eq 6 (p)	Eq 11 (
Prior Achievement	.001	.001	.001	.001
DIT	.001	--	.001	--
Coverage	--	.05	--	.05
TPT	.05	NS	.05	NS
Grade	.01	.05	.05	.05
Friction	--	--	.05	.01
Cohesiveness	.05	NS	--	--
Lower Thought Processes	.01	.05	.001	.01
Prior *DIT	.001	--	.001	--
Prior *TPT	.05	NS	.05	NS
prior *Coverage	--	.05	--	.05
R^2	.670	.600	.671	.621

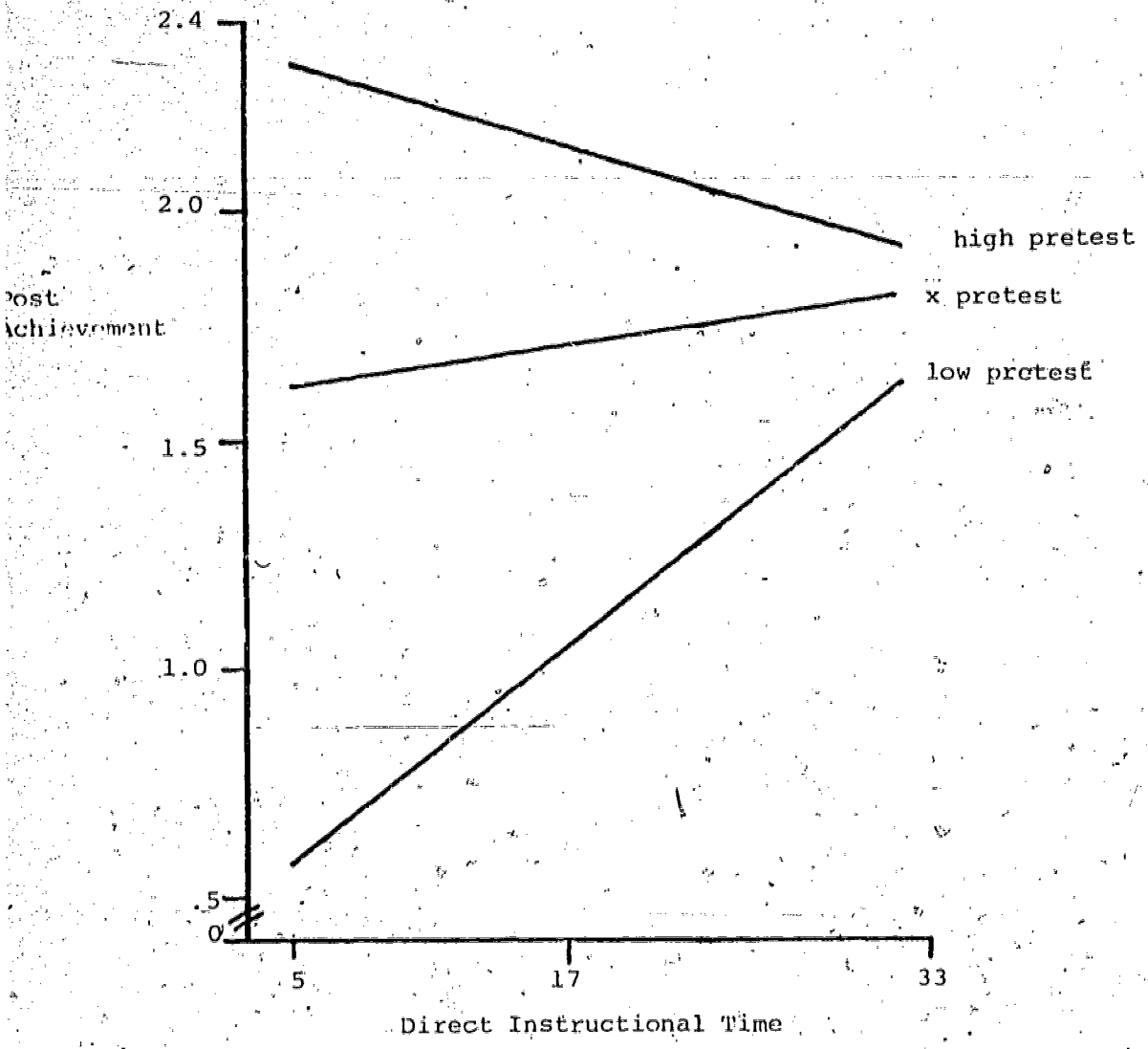

Figure 1. Interaction of Direct Instructional Time with Pretest Achievement[a]

[a]Based on Equation 3.

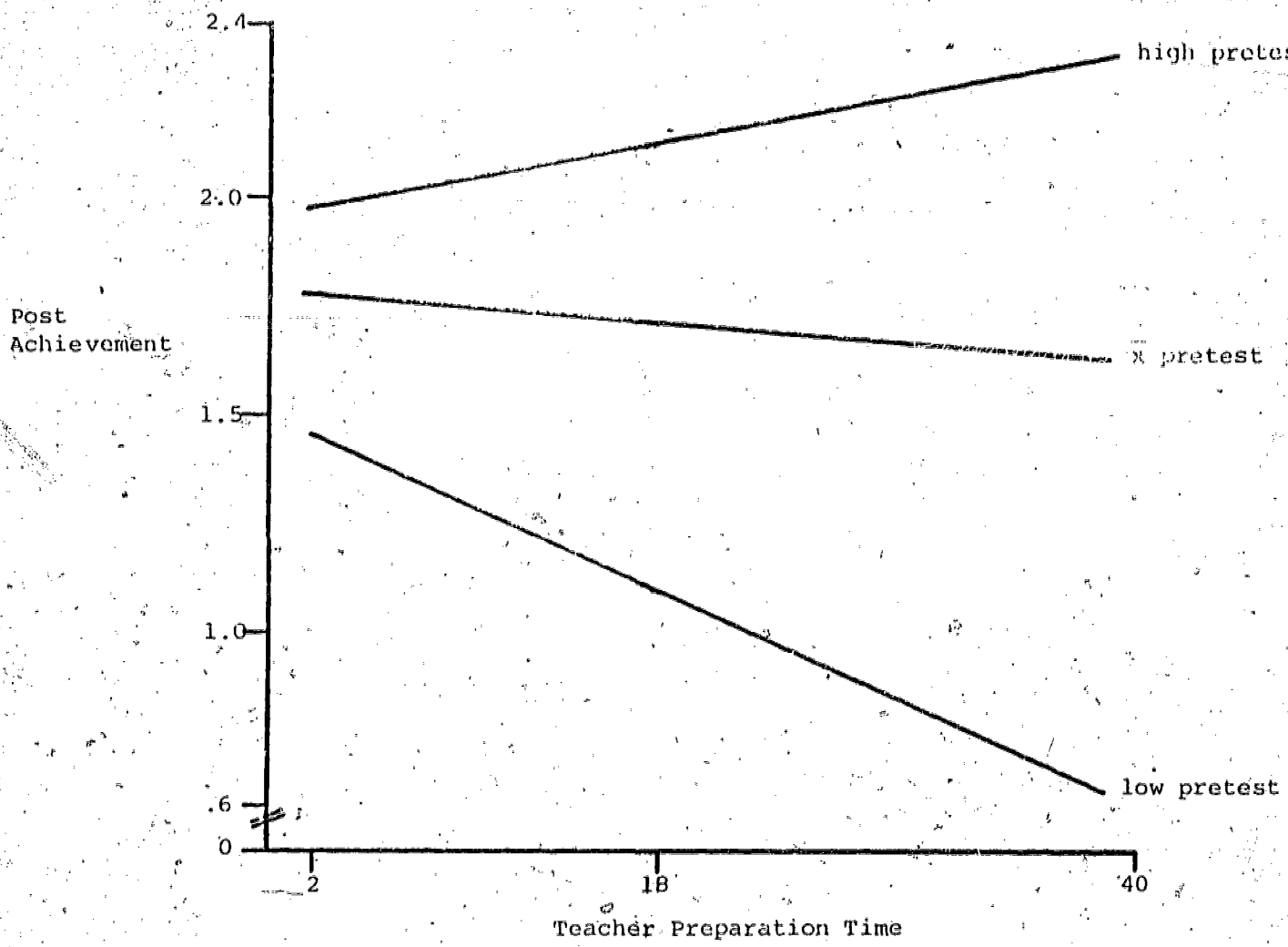

Figure 2. Interaction of Teacher Preparation Time with Pretest Achievement[a]

[a]Based on Equation 3.

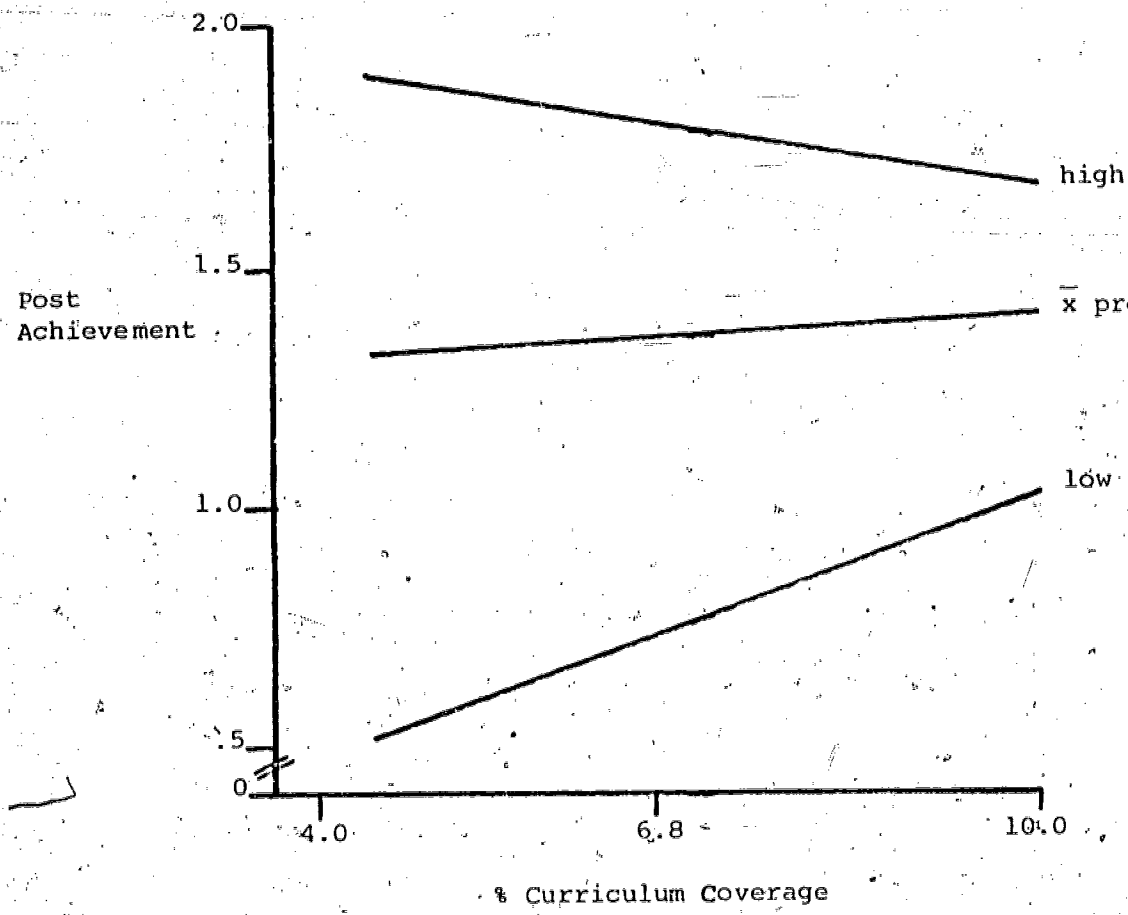

Figure 3. Interaction of % Coverage with Pretest Achievement[a]

[a]Based on Equation 11.